Rubber Agroforestry systems in Kalimantan, Indonesia.

What changes from 1994 to 2019?

Report of the mission undertaken in October 2019 with support from the Forests, Trees and Agroforestry research program (FTA) of the CGIAR.

Entitled "Projet SRAP (Smallholder Rubber Agroforestry Project) /Impact study on 10 years time.

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Introduction

In 2019, FTA program funded a mission to CIRAD to obtain information about the evolution of rubber agroforestry trials plots that were established in the 1990's with ICRAF in 3 provinces; West Kalimantan, Jambi and West Sumatra. The mission could visit only the West Kalimantan provinces. All villages were trials plots were established have been visited (Kopar, Engkayu, Embaong, Pana and Trimulia à except Pariban Baru in Sintang area (due to lack of time) as well as the former SRDP Sanjan villages were project farmers were the very first to re-introduce fruit and timber trees within their project clonal rubber initial monoculture.

This report provide the main results of this mission and an idea of the historical and current trend in terms of local farming strategies. When SRAP started in 1994 in the area, most farmers relies mainly on jungle rubber, an agroforestry system based on seedling with low productivity but high biomass and biodiversity. Most farmers wanted to have access to clonal rubber planting material in order to improve their land and labor productivity. Basicaly clones do produce 3 times more than seedlings. The original idea was multiple: i) provide clone and high rubber productivity, ii) maintain agroforestry practices to profit from advantages and positive externalities, and iii) diversify income through timber, fruits, resins (gaharu, damar…)and other forest products (rattan, medicinal plants, forest vegetables etc ….). In 1997, came in the landscape oil palm though the very high and rapid development of private concessions. Oil palm became in the 2000's the main priority for most smallholders. Today, all forest and most jungle rubber have disappeared to the profit of roughly 2/3 of the area with oil palm and 1/3 with clonal rubber, either in monoculture or agroforestry.

1 History of SRAP, an ICRAF/CIRAD research project (Smallholder Rubber Agroforestry Project).

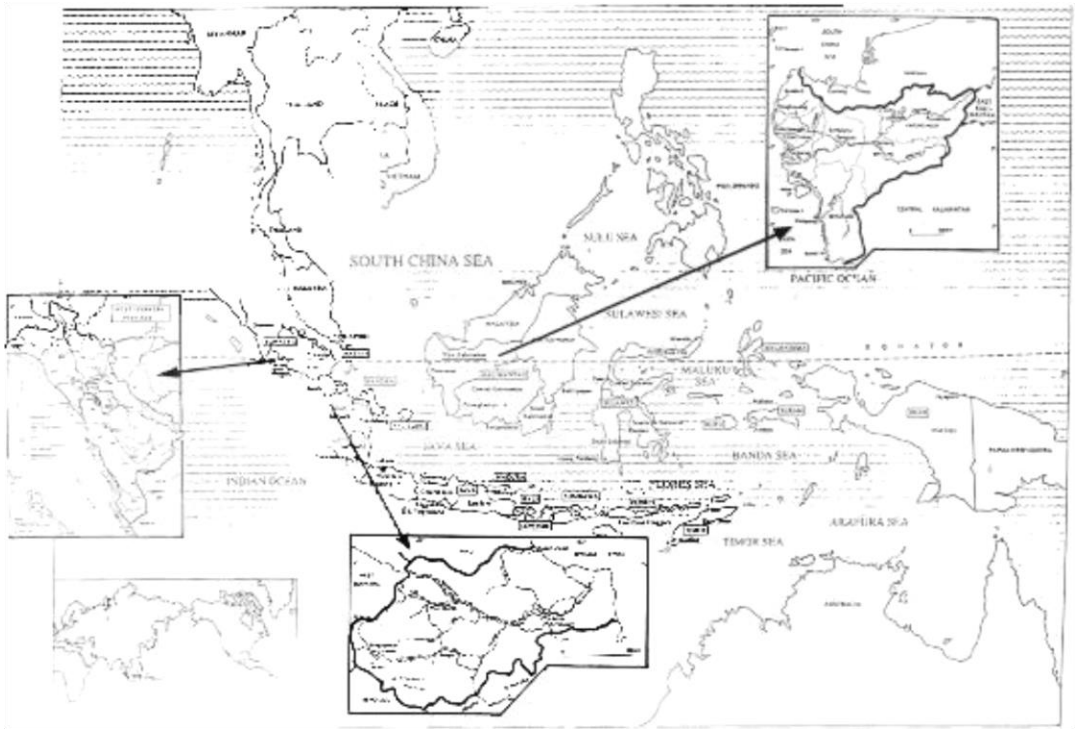
In 1994, ICRAF and CIRAD jointly launched the SRAP-Smallholder Rubber Agroforestry Project in order to set up several on-farm trials based on agroforestry systems in the Indonesian provinces of West Kalimantan, Jambi and West Sumatra. These trials followed three different designs, namely: i) RAS1 which involved clonal rubber plantation and forest regrowth in the interline (the most extensive system), ii) RAS 2 in which clonal rubber was associated with fruit and timber trees and intercropping during the immature period (the most intensive system), and iii) RAS 3 which was planted under the same design as RAS 2 but complemented with fast growing shading trees and the use of a cover crop (mainly *Flemingia congesta*) to get rid of alang-alang (*Imperata cylindrica*) in invaded plots. The main idea was to assess if the different combinations of associated trees and crops with clonal rubber had any long term impact in term of income diversification and agroforestry practices adoption. In SRDP plots in the village of Sanjan where local farmers did implement before 1994 what became ultimately the RAS 2 type agroforestry (figure 1), 25 % of SRD farmers of these village did implement agroforestry plots with success with mostly fruit production and very few timber production. The SRDP AF plots in Sanjan show us that agroforestry practices was possible without significant decrease of rubber production (the main economic output). Therefore, the idea through SRAP was to test several tree combinations to provide a wide range of technical solutions. The main problems were the following:I) to verify that AF effectively did not impact rubber production and in which conditions and did not impact rubber growth as well during immature period in order to tap the trees as soon as possible after planting (generally between 5 to 7 years) and ii) identify the best tree/other plants combinations to fulfil the expected results : for instance in terms of competition with Imperata Cylindrica etc ….

.Each trial was replicated in 2 or 3 villages with a minimum of 7 replications/farms (7 to 10) for each trail with the same deign (planting density, tree association and practices) on the same type of soil and climate. Each trial comprised 6 to 8 sub-plots with a different treatment (i.e. type of clone, type of fast growing associated trees, type of intercrops, type of cover crop, etc…). All trials have been managed by farmers using the same agronomic practices, which were decided before planting.

The total number of trials plot/farmers was 60 in West Kalimantan, planted in 2 main zones, namely: i) Dayak smallholding (mainly after jungle rubber) in local traditional zones and Malayu farmers in transmigration[1] areas (with some presence of *Imperata cylindrica*) trough program or relocalization of people from Java.

[1] Transmigration was a program of the Indonesian government to resettle population from Java to the less populated areas of Indonesia (known as the “periphery”), mainly to Kalimantan, Sumatra, Sulawesi, Maluku and West Papua (Irian Jaya).

Map n° 1; SRAP study areas in Sumatra and Kalimantan



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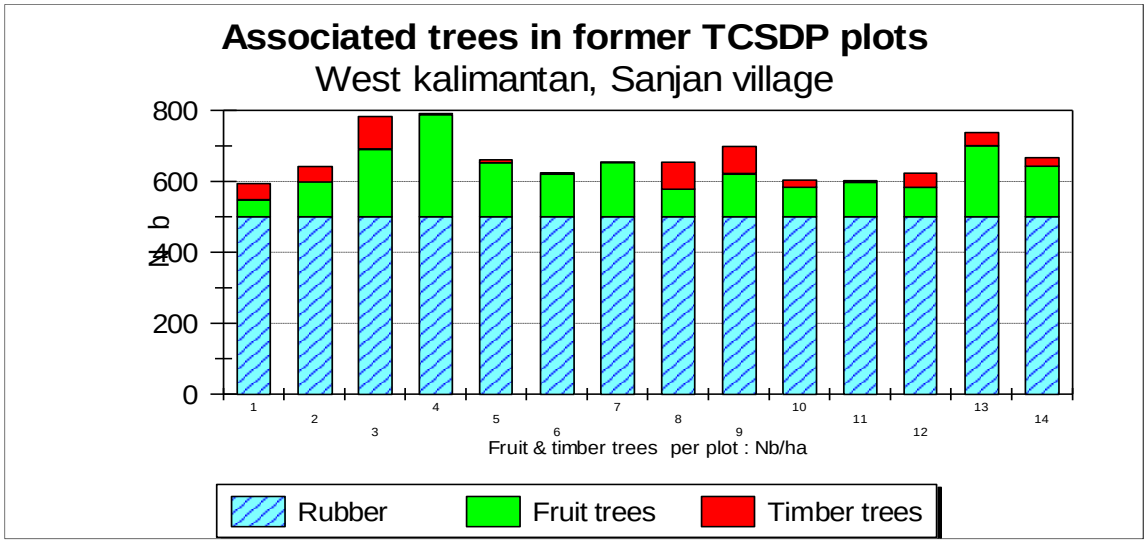
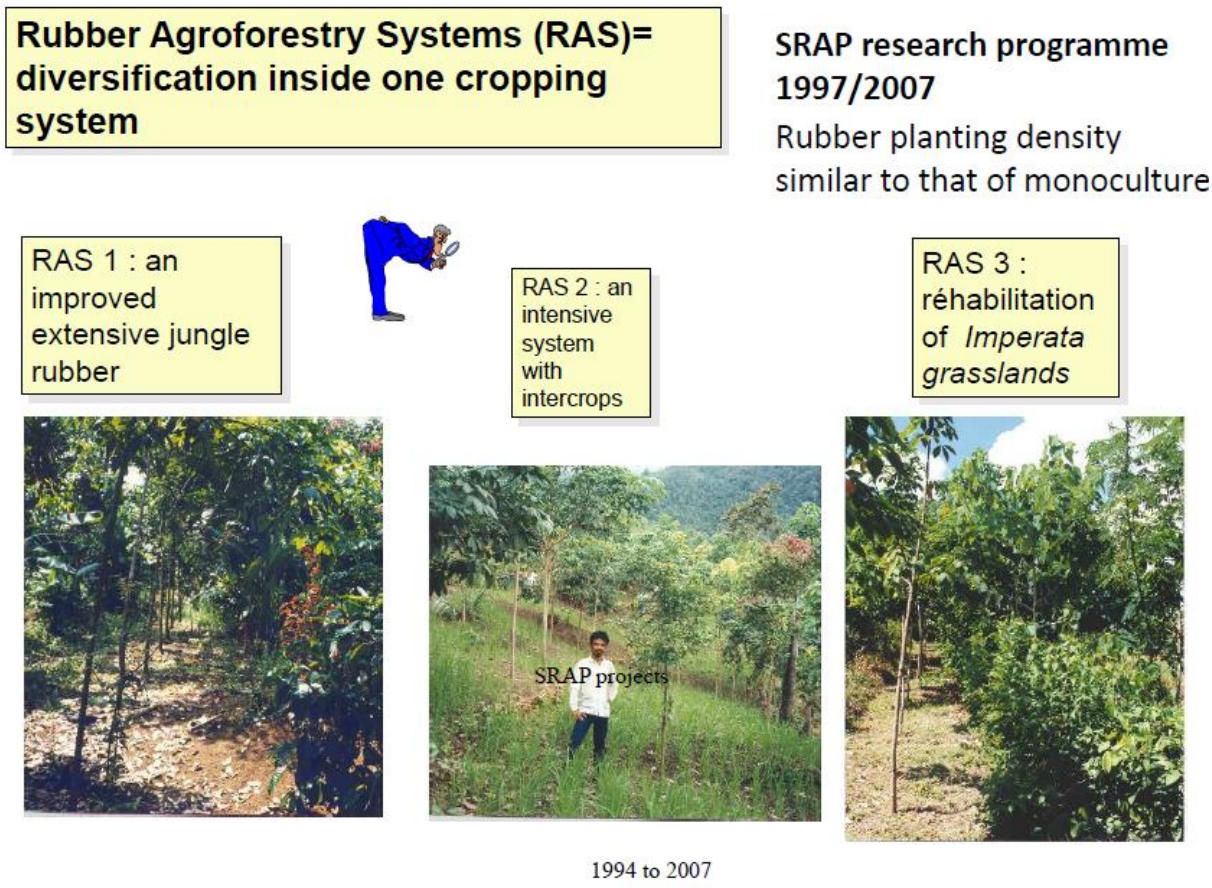


Figure 1: Associated trees in Sanjan SRDP clonal rubber plots that lead to RAS 2 type.

A first series of trials was established in 1994-1996 in the villages of Kopar, Engkayu, Embaong, Trimulia (Sanggau area) and Pariban baru (Sintang area). A second series was established between 2000 and 2005 in Pana (Sanggau area). The main outcomes which were expected from clonal rubber-based agroforestry systems were as follows:

- Income diversification (rubber, fruits, timber …) = better economic resilience,
- No impact of agroforestry practices on rubber production, as long as there are no trees above rubber canopy,
- Reservoir of local biodiversity and « forest effect » on local climate , if widely used, for a better global resilience. The expected forest effect is multiple as well: i) maintain or improve C stock, ii) maintain humidity, iii) rainfall patterns, and iv) access to “forest products”……
- Less soil erosion and better use of water,
- Soil fertility maintenance or improvement, if soil surface is covered,
- Possibility of timber production: rubber farmers might be the very next timber producers,
- A more environmentally friendly system in a broad sense
- Rubber production does not require fertilizers nor pesticides: it is thus already « bio compatible », i.e. for instance for organic farming intercropping.



A comparison of the various systems under study (figure 2) with ancient and recent jungle rubber, poor/good oil palm plantation and monoculture/RAS systems shows -for the year 2000 - that clonal rubber-based systems provide a good level of income compared to any other per hectare (in particular rice or “palawija” or other upland secondary annual crop (soybean, maîs, peanut etc…), usually on a longer lifespan than oil palm if tapping practices are correct (35 years for rubber when it is 20 years for oil palm. The situation is more or less similar in 2019, according to local farmers’ statement but further in depth research is definitely needed to corroborate that perception. The rubber income and perception of rubber interest is of course heavily linked with rubber prices. In the last 30 years, we had in alternance periods of high price (up to 5 US $ /kg in 2011 and periods of low price (0.5 US$/kg in 1999 or currently 1.3 US$/kg in 2019) (FTA report) (see figure n° 3).

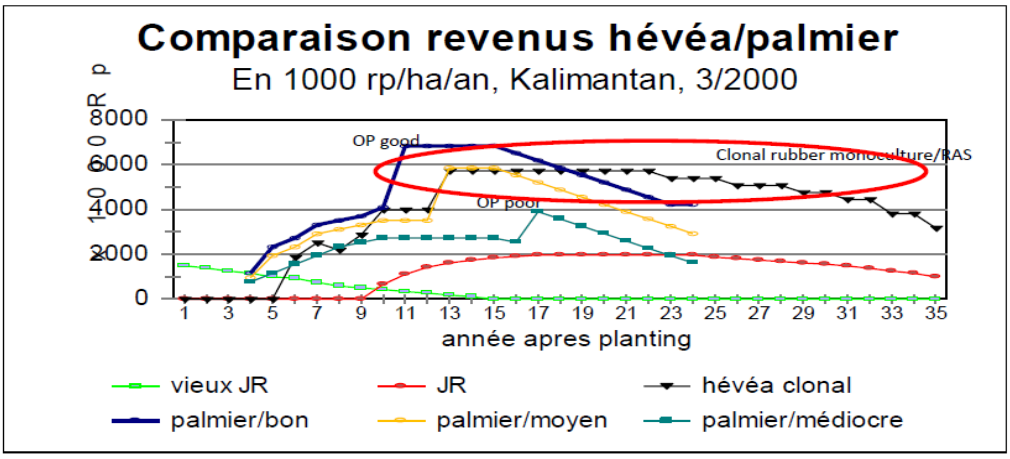


Figure 2: Income comparison for various types of tree cropping systems in 2000 (Oil palm, rubber monoculture and RAS, jungle rubber)

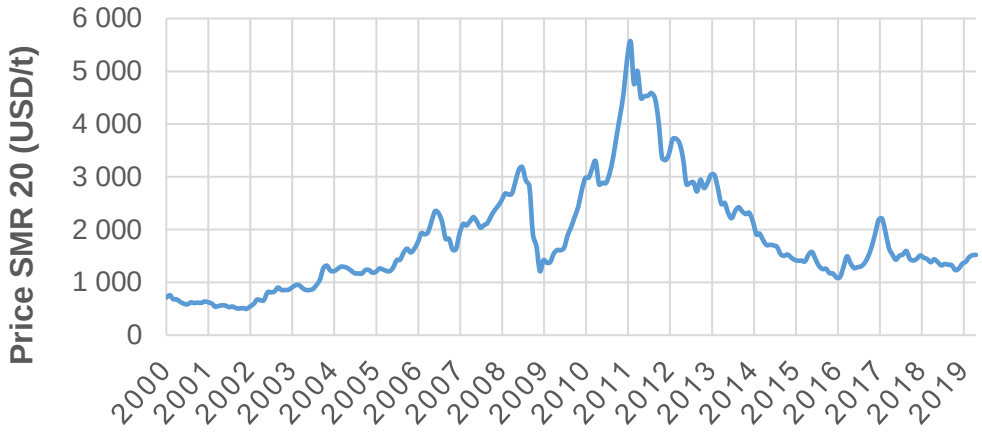


Figure 3 Price of Natural Rubber (Grade SMR20) in Kuala Lumpur from January 2000 to May 2019 (Malaysian Rubber Board, 2019)

Impact of oil palm development in the area

In 1994-1996, during trials' establishment, the oil palm area in the regions under study was close to zero. In 2019, the land use distribution is now as follows:

- Huntan lindung/protected forest: 100,221 ha
- Huntan produksi/potential forest to be converted: 453,300 ha
- Land for plantation: 723,000 ha
- Land covered with rubber: **107,000 ha (52,300 families) = 28%**
- Land covered with oil palm (both estates and smallholders): **283,500 ha (58,900 families)**

Oil palm is now the very first crop for local farmers and estates, even if rubber remains important for local farmers who want to maintain a certain level of crop diversification. We found that most of the jungle rubber area (that covered 90 % of the rubber area in 1994) has been converted to oil palm and/or clonal rubber plantation to a lesser extent. In other words, the majority of jungle rubber has currently disappeared although rubber production is maintained, because clonal rubber yields 3 times more than jungle rubber. Oil palm has been like a « steamroller » in the landscapes under study. Indeed, most local Dayak farmers have exchanged their land at the benefit of oil palm estates (5 ha lost for 2 ha planted provided by the estate to the farmer). Now, most farmers cultivate in average 2 ha of oil palm, 2 ha of rubber (partly clonal and sometime remaining jungle rubber) and a small area for food crops or other crops. These farmers cannot count anymore on land availability as they did some 25 years ago. We do not know exactly what is the proportion of clonal rubber which is currently cultivated as agroforestry: this might reach more than 30 %.

It is important to understand the pros and cons of oil palm and how oil palm has significantly changed land use, farmers' strategies and cropping patterns.

The « pros » for oil palm are: i) low labor requirements: 8 days a month/ha compared to 14 for rubber, ii) secured incomes up to now despite fluctuations, iii) access to homes and some social benefits and iv) new roads and access to markets.

The « cons » are: i) Loss of land according to concessions regulations (5.5 ha), ii) risk of monoculture: less resilience, iii) requires an investment of 700/1000 kg of fertilizers/year/ha and the corresponding capital availability, and iv) recent decrease in fresh fruit bunches (FFB) price.

Consequently, for local smallholders, oil palm is now the number one crop, as jungle rubber has almost disappeared and clonal rubber is still cultivated, partly under agroforestry. Some local Dayak farmers also maintained some jungle rubber as a land reserve while preserving *tembawang* (man-made agroforests with fruits and timber trees under shared social regulation called « adat »). We were able to estimate that in the area of study (in the 4 villages where SRAP has been developed) 70% of available land was under oil palm, 20% under clonal rubber (monoculture or agroforestry systems) and 10 % remained as old jungle rubber and *tembawang, according to farmers' opinion*. In transmigration areas, the situation is different, as most farmers own only 2 ha (sometimes 3 ha) mainly planted with clonal rubber. Oil palm companies did not intend to penetrate these areas with a special status however they are generally surrounding transmigration schemes. These farmers do not have any possibility to cultivate oil palm on new land.

Impact of current low rubber price (since 2013)

It is quite clear that the long period of low rubber price which occurred since 2013/2014 (see figure 3) did not help in favoring clonal rubber plantation, in particular for young

generations. However, old farmers remain convinced of keeping both crops (rubber and oil palm) in their production systems.

Changes in RAS systems

- RAS 1 was found to perform as best for soil fertility maintenance, no erosion and low cost of establishment for immature period, either in 1997 and 2007 during survey implemented at these periods as now in the long run by farmers that did maintain their RAS plots (more than 80 %). This is interesting for most smallholders who are reluctant to invest 2,000 US$/ha for new clonal rubber plantation from their own savings (compared to plantation done by local estates for oil palm with a dedicated credit). Establishment cost and maintenance for the first 3 years were estimated in 1997 at 700 US$/ha.
- RAS 2 is the most widely adopted type, due to the production of associated trees (both fruits and timber recently) despite the fact that poor markets for fruits and timber are real constraints for further development (see pictures 3 and 4)
- RAS 3 did the job in alang-alang (*Imperata cylindrica*) infested environments, with a very good control through the shading provided by associated trees and cover crop (*Flemingia congesta*). Such results were obtained without Roundup in transmigration areas and in some villages like Pana. (see picture 5).

Changes in various trials were recorded and they showed that:

- Conversion to oil palm (20 % of SRAP plots) or to clonal rubber monoculture (20 % of SRAP plots mainly in Trimulia), with agroforestry systems maintained in RAS 1 or 2 (50 % of the SRAP plots) and *tembawang* (10 % of the SRAP plots).
- In Trimulia village (transmigration area): 100 % of rubber plots are now in monoculture.
- Kopar: 80 % RAS 1 (50 %) as sown in picture 2 and RAS 2 (50 %) see picture 1
- Engkayu : 60 % RAS 2
- Embaong : 30 % RAS 2
- Pana: 90 % RAS 2
- Sanjan (former SRDP and no SRAP trials): 50 % of the area remains under clonal rubber
- And some plots were changed into *tembawang* a local fruit/timber based agroforest

RAS1 evolution in Kopar into a RAS 2 (Indi)

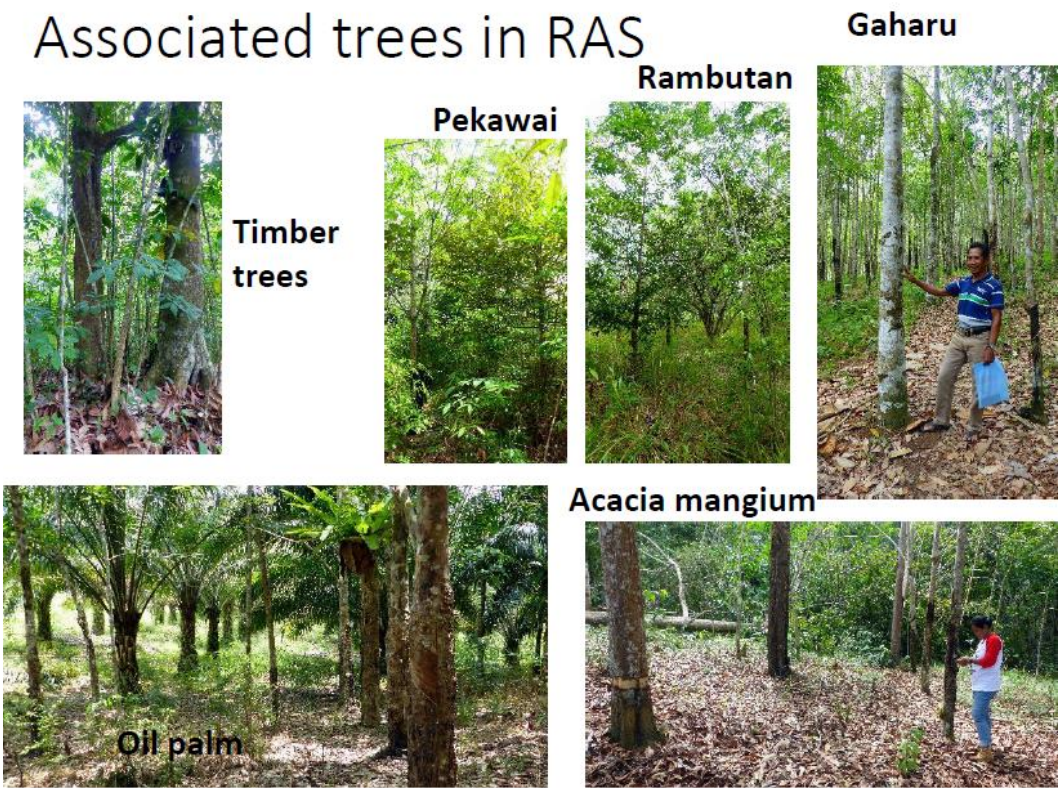
Rubber associated with Pegawai, durian, jackfruit mango, Tekam

Picture 1

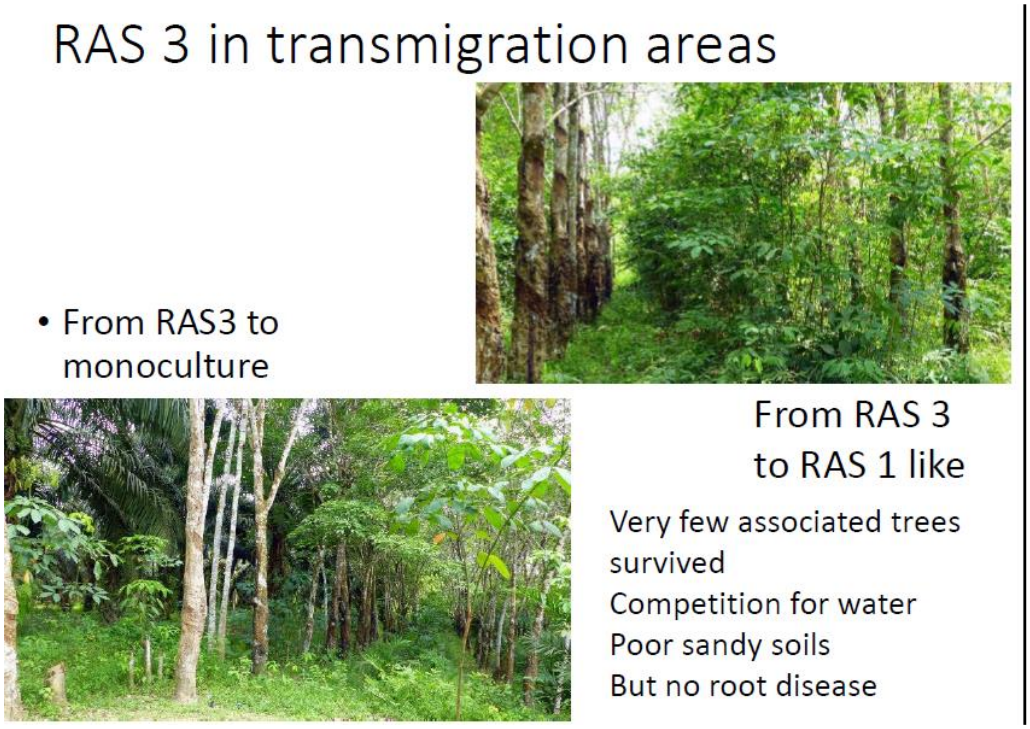
RAS1 remains a RAS 1 Kopar (Jampi)

Picture 2

Picture 3



Picture 4



Picture 5

Comparison between 1994/1997 establishment period and the current situation

Most trials have been established between 1994 and 1996 in the villages of Kopar, Engkayu, Embaong, Trimulia and Pariaban baru. Another set of trials plots have been planted between 2000 and 2005 in the village of Pana. Trials plots have been regularly visited between 1994 and 2007. ICRAF ended up the trials monitoring at the end of 2007 with the completion of FCF funding. The pictures show the situation in 1994/1997, then in 2005/2007 and eventually in 2019.

Pre SRAP project situation

Alang Alang area in Trimulia (Imperata cylindrica

Farmers nursery for clonal rubber planting material production in 1994

Tembawang in 1997 (40 years old in Engkayu): the local traditional non rubber agroforest

Old jungle rubber in 1997 (30 years old in Engkayu): the local traditional rubber agroforest

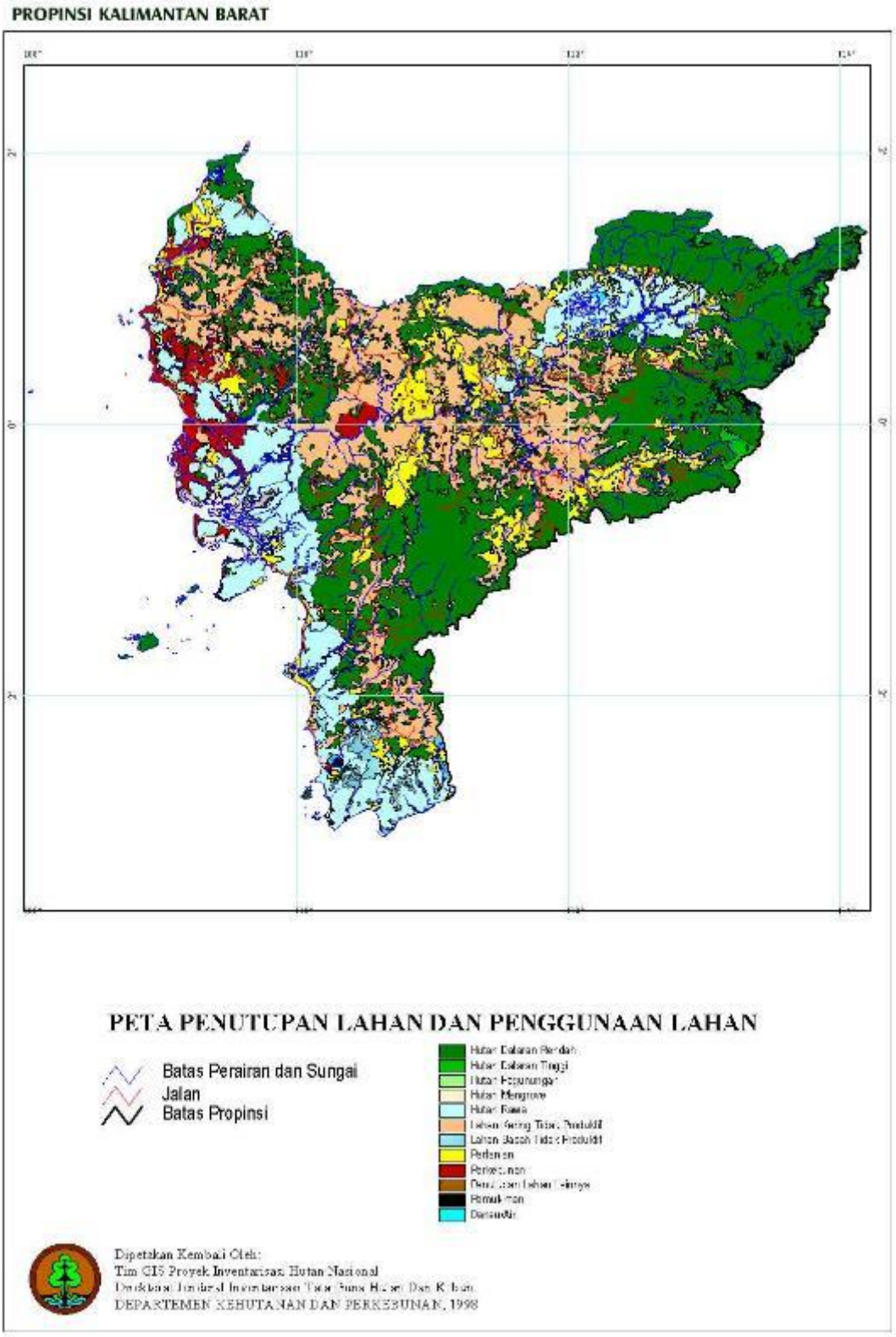
RAS 1: Good tapping practices 1 year after opening in 2001.

In 1997, latex was processed into humid slab using mangle machine.

In 2019, latex is entirely processed though cup lump

The very first oil palm plantation in Kopar in 1998.

The official map of land uses in 1998 in West Kalimantan province



RAS 1

RAS 1 plot in 1997 (3 years old in En gkayu)

RAS 1 plot in 2005 (8 years old) in Embaong

RAS 1 plot in 2019 (22 years old) in Engkayu)

RAS 1 plot in 2019 (22 years old) in Engkayu)

RAS 2

RAS 2 plot in 1997 (3 years old in Engkayu)

RAS 2 plot in 1997 (3 years old in Kopar

RAS 2 plot in 1997 (3 years old in Trimulia with rice intercropping

RAS 2 plot in 2005 (11 years old in Engkayu)

RAS 2 plot in 2019 (22 years old) in Trimulia with associated fruit trees

RAS 3

RAS 3 plot in 1997 (3 years old in Trimulia with *Acacia mangium* and *Flemingia congesta* for shadowing and associated fruit trees

RAS 3 plot in 1997 (3 years old in Trimulia with *Gmelina arborea* and *Flemingia congesta* for shadowing and associated fruit trees

RAS 3 plot in 2005 (8 years old) in Trimulia in monoculture

RAS 3 plot in 2019 (22 years old) in Trimulia in monoculture

Tapping practices and diseases

The main problem affecting rubber production is the very poor quality of tapping practices. Indeed, in SRDP[2] plot with a clone selection based on GT1, we clearly observed the effect of initial training on tapping and D2 frequency (tapping every 2 days). The lifespan of trees is 35 years in Sanjan and Embaong villages were SRDP was developed at the end of the 1980's. SRAP introduced the possibility to diversify access to good clones, with the following selection of genotypes: BMP1, 24, RRIC 100, RRIM 600 and PB 260. Unfortunately, insufficient training on tapping practices at the time of tree opening (between 2002 and 2004) and high tapping frequency (in particular when rubber prices were low and tapping was performed everyday) significantly reduces the lifespan of rubber trees down to 20-25 years in trial plots.

The second problem acknowledged during the present mission was the impressive impact of *Fomes*/White Root disease and obviously another root disease (so far unknown or not identified) on rubber trees during their whole lifetime, in particular in areas where trials were established after secondary forest or old jungle rubber, with a very high amount of root biomass remaining in soils. Some trials have been severely impacted, with more than 50 % of trees destroyed in the last 4 years. Their final decision therefore is to replant in the very next future the plot most generaly with clonal rubber.

Do agroforestry practices increase risks of *Fomes* and other root diseases?

So far, it seems that there is no difference in susceptibility to fungal attacks between monoculture and agroforestry systems. The main factor is the precedent crop or land use before planting (Embaong/rich soils/old jungle rubber). For instance, there is no such impact on soils initially covered by *Imperata cylindrica* (Trimulia/sandy soils/alang alang)

What remains from original « village budwood gardens » provided in all SRAP villages to local communities?

Community budwood garden (BG) have been established in each village, in order to guaranty an access to good quality and cheap planting material for farmers. This was in response to the demand from farmers which focused on the access to clonal rubber (1994/1996). These BGs were under the SRAP farmers' group management. Local farmers were trained to grafting techniques and nurseries were established in the aim of producing grafted clonal rubber plants.

Farmers' interest for BGs has been virtually « killed » by the rapid development of oil palm which occurred in the 1990's. Production of both budwood and clonal rubber

[2] SRDP for Smallholder Rubber Development Project funded by the world bank from 1990 to 2000)

plants has been launched and maintained for 5-10 years and locally sold. Then BG have been abandoned around year 2010.

Today all is lost although it's time to replant rubber… Only one single BG remains active in Pana. De facto, we are back to the 1994 situation with poor access to planting material for local smallholders.

Conclusion

In the region under study, the major change in land use and farmers' strategies has been clearly the rapid and significant development of oil palm which quickly became the priority number one for local smallholders. In the meantime, local estates took over most of the available land for their own oil palm plantations. Meanwhile, low rubber price hampered any interest in rubber cultivation.

Despite this situation, smallholders did not want to abandon rubber definitively. Rubber is still planted, as it provides a better use of available family labor, in complement of that used for oil palm production and income diversification (monoculture and RAS 2 mainly)

We are back to the same problems and same situation that we faced in 1994: poor access to clonal planting material, no training on tapping frequency and practices but with some knowledge on clones and AF practices. It seems that there is no transmission of rubber cultivation techniques to young farmers and sons.

All trials are at the end of their lifespan, which was reduced down to 20-25 years due to diseases and poor tapping practices. Agroforestry practices have been considered as very interesting for most farmers: i) during the immature period of rubber trees, for a better valorization of land with intercrops or reduced costs of establishment depending on the type of RAS and 2) income diversification (either for self-consumption or marketing, for some fruits and timber) and improved farm resilience and less dependency to commodity price volatility.

The lessons learned

- Rubber agroforestry trials came right in time in 1994, with a strong demand from farmers for systems providing low establishment cost and income diversification: the right time at the place, BUT….
- Oil palm came in 1997 with a very strong pressure from companies (through the policy of concessions) providing a lucrative alternative to rubber cultivation with full credit (but loss of land) and better return to labor.
- Interest in agroforestry practices remains high for old men but no interest is witnessed from younger generation…
- It is now time for rubber replanting as trees are old, and the same old story remains (access to planting material)

- Good tapping practices (tapping school and training, technical information on panel management, upward tapping ….) are essential to be able to maximize tree lifespan up to 35 years long.
- Important impact of white root and other root diseases in areas with forest or old jungle rubber before plantation…(what would be the implications, especially for replanting in these areas?)
- Low rubber prices especially compared to palm oil do not help in maintaining farmers' interest in rubber cultivation.

Most trial plots are now at the end of their life, due to the high impact of diseases and poor tapping practices. Most trees will be cut within the next 3 years.

Suggested follow-up

It would be very interesting to do an in-depth socio-economic survey involving all SRAP farmers in order to assess the current situation of farmers' income (from oil palm/rubber and any other sources), and their ongoing and planned strategies and to explore the reasons governing their present interest in clonal rubber cultivation and agroforestry systems.

We could use the Olympe[3] software for income simulation and budget analysis (Penot, 2012). A prospective analysis could be performed to assess the impact of oil palm and rubber price volatility. The survey could be implemented in the following villages: Kopar, Engkayu, Embaong and Pana in Dayak area, Trimulia and Pariban Baru in trans- migration areas, as well as in Sanjan for former SRDP farmers with up to 80 farmers.

Three major questions are clearly part of the research agenda:

i) What is the impact of fruit production from agroforestry systems on food security and diet quality of local families,
ii) What is the impact of timber production, both for self-consumption in households and marketing,
iii) To what extend such AF systems are able to provide better climatic resilience for both rubber and intercropped varieties?

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[3] Olympe is a French software developed by INRA/CIRAD/IAMM to model and simulate farming system budget with economic analysis at plot and farm level. It enable as well to model evolution on 10 or 20 years for prospective analysis.

Annexes

Annex 1: Description of the current project

Rationale

Although the monoculture of rubber has long been favored politically and institutionally, recent recognition of the interest of agroforestry systems is of interest to research and development institutions as well as policy makers.

It will be particularly useful, 25 years after the first works and 10 years after the official end of the CIRAD / ICRAF Smallholder Rubber Agroforestry Project (SRAP), to return to the original sites, in order to evaluate the evolution of agroforestry practices, farm trajectories, technological paths and associated peasant strategies.

Scientific procedure

• Qualify and quantify the impact of completed programs for the selected province. Have the trials conducted with small local producers led to an increase in agroforestry areas, an adaptation of the systems or their total or partial abandonment?

• Analyze the original systems proposed by the Project: To what extent has the diversification of revenues from forest systems effectively contributed to reducing the impact of rubber price volatility and improving the resilience of farms?

• Identify the new national / local partners (Yayasan ...) numerous since the "Reformasi" of 1998.

Expected products
A report in English, which will include an historical analysis until today, and will, based on the identification of the followed pathways on the ground, identify constraints and/or opportunities to which famers and stakeholders were confronted to, how they resulted in different trajectories being followed. The paper will identify opportunities for a possible future development of sustainable rubber. It will target areas of Kalimantan - Kebupaten Sanggau - where the Dayak people were very interested and motivated by the project, but who also experienced in the same period a very strong development of oil palm from 1998. The project is intended to validate (or not) the initial components and expected benefits of rubber agroforestry systems and to be able to place them in a context of strong competition (or complementarity) with the oil palm. The project will be conducted with the participation of ICRAF, GAPKINDO and IRRI (Indonesian Rubber Research Institute).

Impact
The project to be visited is the Smallholder Rubber Agroforestry Project (SRAP) that was a joint CIRAD / ICRAF project, conducted from 2004 to 2007 and focused on the analysis and development of agroforestry rubber production systems. It is based on a unique experimental network, located in Kalimantan.
The present project offers a real opportunity to revive the joint activities with the partners ICRAF, IRRI and GAPKINDO: it will allow us to explore the possibilities of mobilization and collaboration for new projects, and also to compare the situation with that described by our recent studies in Thailand, where the conditions are complementary and different (organized markets especially for timber).

Annex 2 photos

RAS 1 plot in Kopar (plot Indi). 2019

RAS 2 plot as a monoculture in 2019 (Kopar/plot Indi)

RAS 1 in Embaong (plot Lidi) as a monoculture with severe root disease 2019

Oil palm and rubber landscape 2019

Poor tapping practices 2019

The new leaf disease *Neofusicoccum ribis 2019*

RAS 2 in Engkayu (plot Andrea): destruction of clonal rubber by fomes like fungus disease.

RAS 2 evolving into RAS 1 in Engkayu; 2019, (plot Angkong)

RAS 2 in Engkayu, 2019 (plot Francisco)

RAS 2 plot in Kopar 2019 (plot stepanus)

RAS 1/2 plot in Kopar 2019 (plot sudin)

Seedlings in between clonal rubber in Pana 2019 plot Ating)

Carpophore of fungus disease in Pana

Rubber and oil palm in Pana 2019 (plot Busin)

Plot RAS 3 in Pana2019 (plot Dubuk)

Plot RAS 2 in Pana 2019 (plot Ibun)

Plot Rubber and Inseminated Gaharu in Pana 2019

Local Tembawang in Pana 2019

RAS3 in monoculture in Trimulia 2019 (plot Margono)

Annex 3 available publications and documentations on SRAP

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